

Solid Waste Management in Puebla. A Systems Dynamics Approach

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Abstract

This paper presented a preliminary attempt of bridging a gap existing between traditional approach to solving public administration problems and the System Dynamics perspective. The problem of solid waste in Puebla is a practical context in which a model is developed. The model and its runs prove that present official definition of the problem is wrong and that the solid waste recollection and recuperation could be converted from a resources consuming to resource generating process. It also shows how the municipal budget assigned to cleaning service can create a new reinforcing loop that links the profit of the companies involved in the refuse recycling industry with a decrease of solid waste contamination in Puebla.

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"There are many countries and cities deserving that another "Beyond the Limits" prophecy be written - this time especially for them. One of these is Puebla in Mexico".

Anonymous opinion expressed in local TV

Introduction

Every place is a miniature of the universe. We may worry about the future of the world, but that future begins here and now. The author's "here and now" is a remote urban complex in Mexico having about 1.8 million inhabitants: its name is Puebla, A. D. 1994.

The extraordinary and rich historical heritage of Puebla made this city to be internationally known as a "Reliquary of America". Its monuments, constructed with lime, plaster, wood, and quarry from Santo Tomas are well represented in different buildings and styles. Hence one can find all kinds of constructions, in baroque, churrigueresque, neo-classical, and others - the city is an architectural paradise by preference. Puebla's cultural treasures have won it another title: "Puebla: Cultural Patrimony of Mankind".

Puebla is one of the most ancient, sacred, and historical urban complexes in Mexico and Mesoamerica. Its population, now counting approximately 1,800,000 inhabitants, has been growing steadily at the rate of 2-3% during the last 5 years. That process is completely uncontrolled and has always remained outside the range of local and federal authorities. The city is also a natural reservoir for people of Mexico City willing to move to nearby province; it is estimated that only after the 1985 earthquake, no less than 35,000 people moved from Mexico City to Puebla. In addition, uncontrolled immigration from surrounding rural areas is resulting in chaotic growth and uncontrolled urbanization, mainly in most remote and poor areas of the city. This causes deficient urban services, particularly regarding the air and water pollution and industrial and community waste recollection. This latter, the problem of solid waste management and municipal capacity of controlling it is considered one of the principal weaknesses of the region and the city.

Puebla suffers all political and economical diseases of the country it belongs to. Excess of political outrage causes that public management structure is changing not according to professional quality of public servants and public needs but due to their political merits for ruling party. Public problems are solved on a short run basis or are not solved at all. Some of the problems are hardly detectable, other form a basic criterion for the civil assessment of the quality of life. All determine the quality of the city and country.

Every change of the political configuration results in new hopes and expectations that a new administration would really confront and handle problems not on that short-sighted basis. At the same time the number and quality of civil initiatives is increasing; some think of social revolution, a majority has more constructive mind: they worry about constructing a new reality instead of searching sudden changes.

Two years ago, a group of scholars and researchers, representing different academic areas in the University of the Americas - Puebla, decided to form a team interested in fostering constructive changes in public management. In addition to the loyalty and political reliability, public managers should represent a good knowledge and methodological skills for solving public problems - task almost impossible if we trust a traditional academic preparation and linear approaches taught in schools. Less possible yet, if we trust that political qualifications and declared interest in public problems is good enough for solving them. That group, composed of nine scholars and researchers representing different specialties and deeply attracted by the System Dynamics methodology, together with students preparing their terminal theses, decided to develop a technical (hardware) and methodological (software and mental background) for handling public problems in Puebla. Solid waste management is one of them.

Research project on the solid waste management in Puebla has had no scientific ambitions. From methodological point of view, it is a very provocative and promising perspective to have to look for a common language for five scientific disciplines involved in. Practical importance of the project depends exclusively on the research team's convincing power. First attempts to collaborate with municipal authorities have resulted ineffective, at least for the problem under consideration. The System Dynamics modeling and simulation is still (for authorities) more an academic dream than a solid platform for problem solving. As

one of the mayor deputies taught us: "You can not play with social problems and enjoy it. The matter is much more serious than academic interest".

Solid Waste in Mexico and Puebla. Problem and Basic data

The improvement of solid waste management and its adequate treatment is one of the most important issues throughout the world. Catastrophes, mortal contamination, prolonged results of our carelessness provide us with daily examples of the cost we have to pay for our growth and lack of imagination. According to prevailing opinion, developed countries - transforming more resources - are much more exposed to environmental problems than developing countries (It is either a white lie or a harmful justification of our carelessness; contrarily to developed countries, developing countries have no resources to spent on environmental issues; they spent their resources and they define their priorities in accordance with fostering (at any cost) economical development (growth?), leaving environmental issues for "better times" and risking our health and lives.

Daily generation of solid waste in Mexico counts for approximately 53000 tones^{1/}. An average citizen of Mexico contributes to this amount with approximately 0.7 kg per day. Although everyone produces solid wastes, their disposal creates a problem primarily in urban areas, and the more concentrated the population, the greater the problem becomes. For this reason, national totals and averages can not be used in determining the amounts of refuse to be disposed locally. For instance, Mexico City produces approximately 17000 tones of national solid wastes which is approximately one third of the total amount in the country. Only 85% of these 17000 tones is recollected, 5% of recollected wastes receives a technical treatment; 95% of recollected wastes are deposited in landfill sites that are rarely covered with compacted earth, not to mention their ecological closure. At least 15% of the total waste amount remains on the streets; this refuse is never recollected. According to experts' opinion, the waste problem in Mexico City has no practical solution, mostly due to elevated costs (it is estimated that a satisfactory solution to that problem would cost about 130% of Mexico City yearly production value - about 50% of the whole country). By the year 2000, Mexico City will have approximately 32 million inhabitants; as the largest city in the world, it will generate no less than 35000 tones of highly harmful (increasing industrial ratio with deficient cleaning system) wastes. If we do nothing now, a solution of this problem should have to take about 45% of the national GNP in 2000.

Puebla is much smaller, less concentrated and industrialized. Official sources show that Puebla's daily waste refuse is between 1400 and 1800 tones, 55% of which corresponds to household wastes. The capacity of municipal cleaning system is very insufficient; it can only recollect about 70% of the total refuse; that amount is deposited in open landfill sites close to the city. Recollected wastes are never classified and selected; wastes are left and deposited as they go.

According to official data 30% of total solid wastes remain on the streets and public places. Municipal cleaning system, however, is not the in all zones of the city. Only a small part of Puebla receives a regular (daily) and sufficient service. The rest of the city, at least 80% of total urban area, is lacking a regular service. What is worst, marginal areas of Puebla not only do not receive a regular service but they also serve as illegal sites for solid waste deposits. In 1993, though public surveillance system is not very sensible to that problem, as much as 400 illegal waste deposit acts were detected and fined. This corresponds to approximately 2400 tons of refusal thrown purposefully in the town, mostly from the most dangerous fabrics and hospitals.

In Puebla we have approximately 250000 automobiles, 55% of them invading any environmental legal regulations and very tolerant Mexican norms. Air is given and self-cleaning; there is no necessity to be worry abut it - God does it. Water deficit is calculated in Mexico is calculated on the level of 70% and in Puebla - 80% of total water consumption. 95% of water sites (either natural or artificial) are used as another (legal) solid waste deposit site. 95% of public water supply is contaminated; at least 50% is harmful or fatal if consumed without boiling or chemical treatment. 40% of water is lost due to the poor quality of water system.

^{1/} All data used in the paper were excerpted from INEGI Statistical Bulletin, 1993.

Theoretically, Puebla has a very sophisticated solid waste recollection system. Public service guarantees that any household is provided a cost free recollection of solid waste once a week. If it is not enough, additional cleaning must be bargained with the colons. According to official data, suggested additional charge is:

- * 33/1000 of monthly minimum salary per day in the case of 7 days coverage (times the amount of kilograms per month per community),
- * 25/1000 of monthly minimum salary per day in the case of 6 days coverage (times the amount of kilograms per month per community),
- * 6/1000 of monthly minimum salary per day in the case of 1 days coverage ((times the amount of month kilograms per community).

Daily, Puebla's households yield 900 tones of solid waste daily, 200 tones stem from commercial sites, industry generates about 400 tones, and additionally about 300 tones are generated by popular in Mexico public markets. In short, each of us is responsible for approximately 990 g of solid waste per day. Regarding the waste recyclable structure, we find that:

- * 49% is composed of organic refuse,
- * 20% is paper,
- * 7% - plastic,
- * 6% - glass,
- * 4% - different metallic substances,
- * 14% - other of less importance.

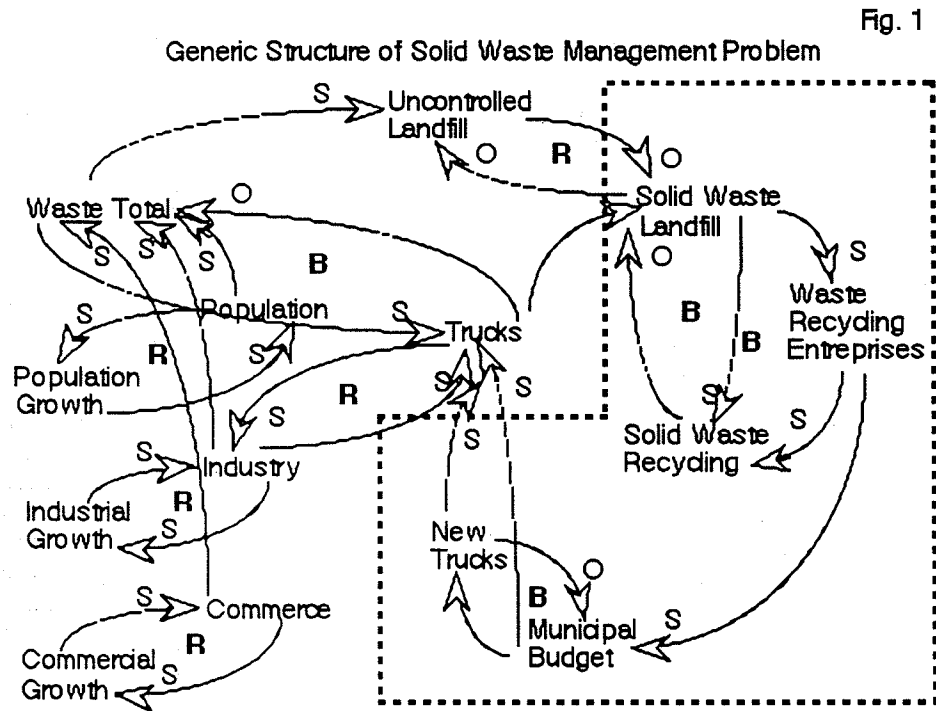
Certainly, even the richest country can not afford a complete recycle of the solid waste. Presently, Puebla knows only 3 forms of treating the solid wastes. First, local government's official service is able to recollect no more that 1400 tons of solid wastes daily. Second, this amount of solid waste is deposited in a unique municipal waste disposal that has 278000 tons of capacity; as it has been used for years, its present capacity is about 15% of the nominal capacity. Third, in addition to previous options, many enterprises pay considerable sums of money for taking away their solid wastes, without asking for official permission or license. This illegal service is supported, as many documented sources claim, by 2 underground associations of so called "pepenadores" - people living on trash selection; they hand on selected waste to a "headquarters" and get moderate sums of money for this work.

Considering municipal budget expenditure for solid waste recollection and disposal, 1 ton of solid waste costs approximately N\$60.00 (about US \$18.00). The Cleaning Department maintains 17 municipal trucks recollecting trash from the streets and it has to pay service offered by other 97 trucks belongings to 3 private enterprises licensed to do that. It is estimated that each truck can recollect and transport approximately 12.4 tons of solid wastes per day (its nominal capacity is 6.2 tons and it usually makes 2 tours per day). Yearly budget for the whole cleaning service is N\$13.055.000,00 and the local government exceeds by more than 14% sums assigned to cleaning expenses.

Solid waste recollection and recycling is a very attractive business. There are at least 20 more solicitudes for the cleaning license but for some unknown reasons cleaning service licensing is extremely slow. This could be a chance to solve the solid waste problem in Puebla. Apart of the technical capacity of present cleaning operation, there is a difficult budgeting problem; yearly budget for the Cleaning Department usually corresponds to the previous budget modified by an approximate increase of the Puebla population. Cleaning service, however, is paid on the market basis and it is increasing constantly (inflation rate and market demand). In a long-run it is neither possible to maintain costly service provided by the licensers nor the government can keep the solid waste recollection at the present level. Puebla belong to one of the most dynamic, in terms of the population, industry, and commerce growth, cities and areas in Mexico. Although it is very difficult (if not impossible) to calculate precisely yearly population increase, most of that increase corresponds to rural immigration and typical for those people carelessness for refuses. In short, the solid waste problem in Puebla has come to the dead-end and its management becomes perhaps the most important and politically vulnerable criterion for the government evaluation.

Solid Waste Management Options in Puebla. A System Dynamics Model

Presented basic data allow us to construct a generic model of the solid waste in Puebla. We will analyze two complementary version of that model: one corresponding to the present state and explaining what will happen if we do not decide to act immediately. Complementary model (separated with a dotted line) deals with basic options in the solid waste management: cleaning service licensing and solid waste partial recycling (Figure 1).

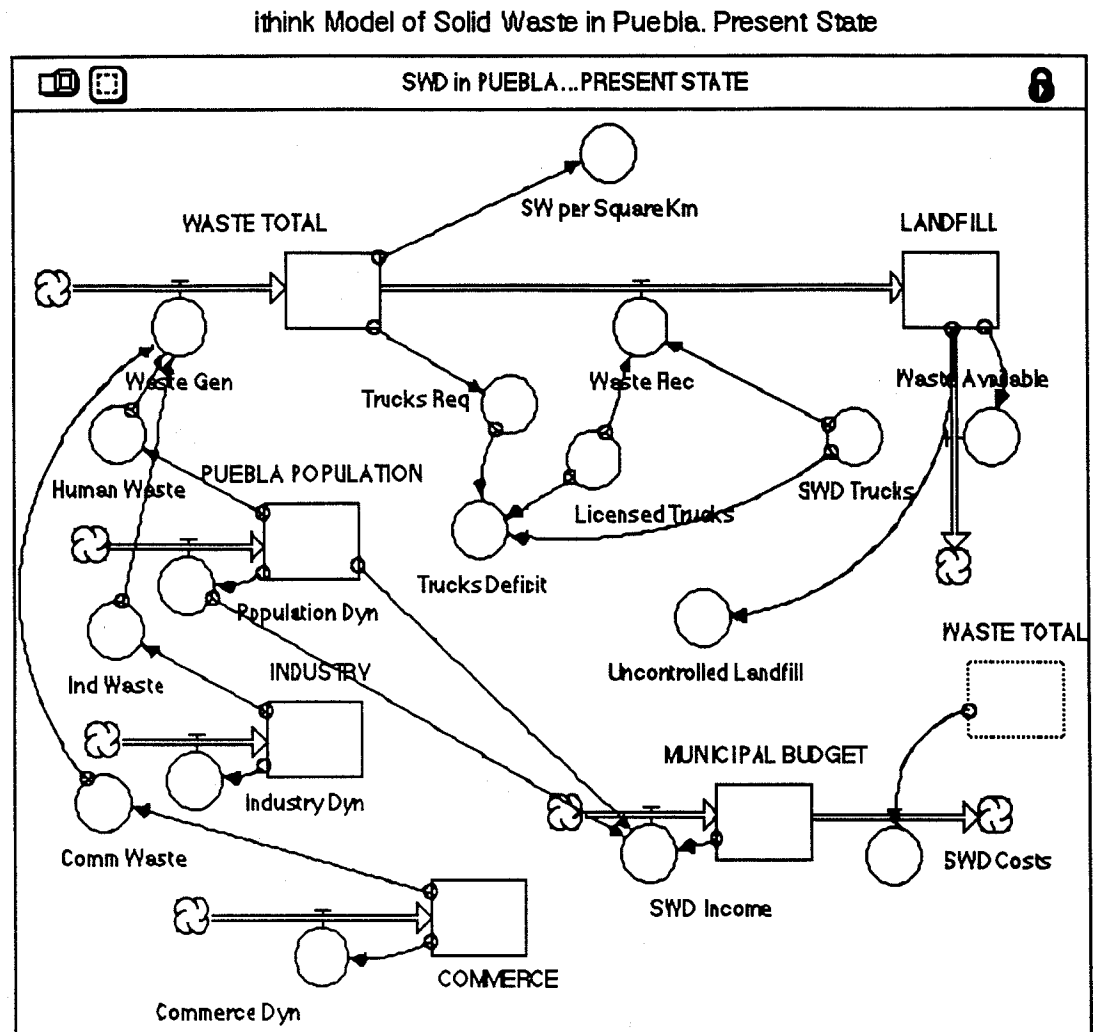


Source: author's elaboration.

In general, the solid waste problem in Puebla suffers from an excess of reinforcing loops that determine explosive character of the waste accumulation accompanied by few balancing loops that could control the problem. Solid waste accumulation is caused by 3 factors: population growth (which also includes uncontrolled immigration), industry growth, and commerce growth. Total amount of solid waste is recollected by trucks and "deposited" in already exhausted sanitary landfill site. Recollection capacity depends directly on the number of trucks. Total amount of solid waste is, theoretically, landfilled. Practically, as this deposit's capacity is not sufficient, the trucks keep transporting wastes to this site and overload it. It is simply a disguised way of depositing solid wastes in the urban area again. From this point of view it makes little or no difference between recollecting and not recollecting generated trash. High recollection cost (N\$60.00 per tone) and modest municipal budget makes it practically impossible to recollect all waste; even if it would be possible, there is no safe destination for it.

Perhaps most important (though invisible on the diagram) loop is that corresponding to the authorities' incapability to learn and to find a sustainable leverage point for the problem. For the Cleaning Department, solid waste is only a resources consuming factor. Though it is easy to figure it, no one has calculated that given the cost of the cleaning service and present budget deficit, we can expect that within short time either the government will have to pay out huge sums for the service (much above the present 13% deficit) or the city will sink in refuses. Figure 2 presents it think model corresponding to the present state of the problem.

Fig. 2

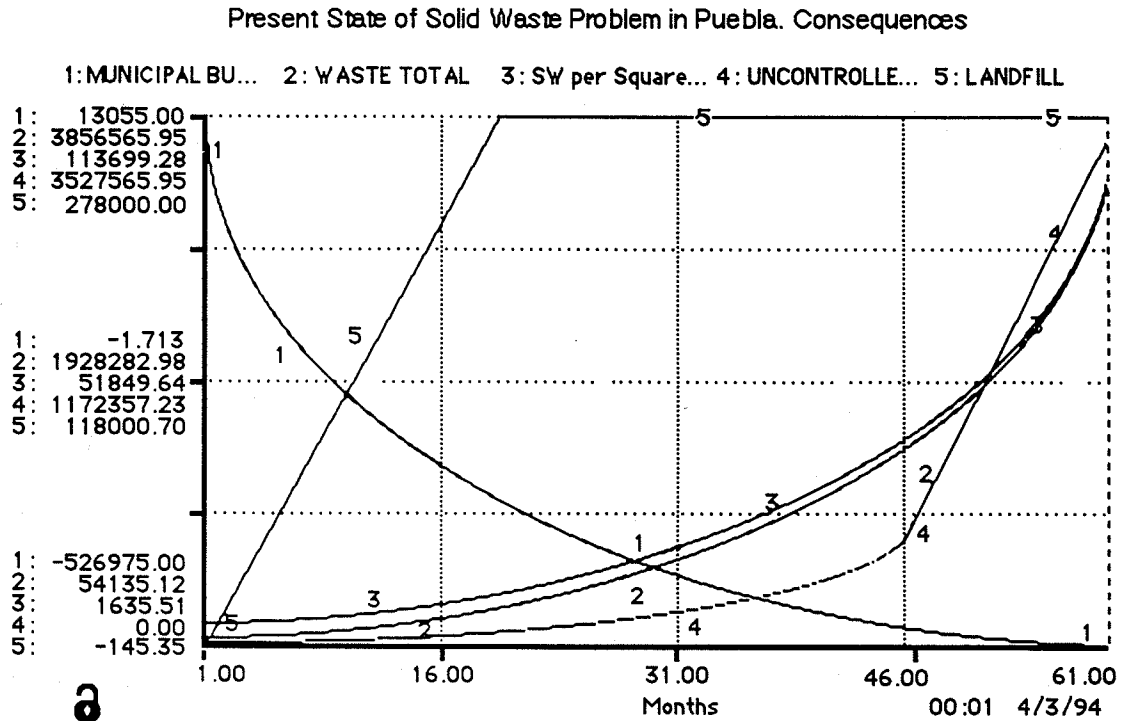


All commented tendencies and prediction are clearly detectable when we run the model (Fig. 3). Initial data do not contemplate existing deterioration of the environment in Puebla. We also decided to assume that the whole problem starts from the beginning; the only available sanitary disposal is empty, there is no budget deficit, and no illegal deposit sites exist. Even under these fictitious and favorable circumstances the solid waste problem leaves no doubts regarding its magnitude. First of all, municipal budget - balanced at the beginning - will suffer high deficit within 5 months from now. In the 5 year perspective, the government will have to pay 40 times its present budget, amount which will be impossible to spend.

Existing sanitary landfill site will be fill out within no more than 2 years. Construction of a new one would cost approximately N\$290.000.000,00 (US \$95.000.000,00) and this expense is not included in the run. From that moment on, an extensive illegal refuse deposit will start; given the amount of solid wastes in Puebla, it will not take a long time to reach the present stage of the environment deterioration.

There is a new reinforcing loop in the model (see: Fig. 4). The amount of solid waste is a factor attracting non-governmental investment in the trash recollection and recuperation. This new capital in the solid waste industry is basically profit oriented; profit making, however, is conditioned by the solid waste amount recollected in the city. More profit, cleaner streets and public places and less budget constraints (possibility to spend money on the solution of other public problems)...It could be, therefore, a self-controlling and regulating mechanism causing that the more solid waste, more enterprises interested in investing.

Fig. 3



The dilemma of "paying or littering" could be solved by the re-designing present restrictive policies. The government seems to be reluctant to issue more licenses for refuse recollection; considering that picking up solid wastes does not solve the problem (no adequate sanitary deposits), this attitude is easily understandable. One possible leverage point could be the conversion of the solid waste problem from the resource consuming to resource generating process.

The point of departure for that conversion could be the opening of another reinforcing process in the waste problem structure. Solid waste recycling would be a very profitable business if the government could create appropriate institutional conditions for that industry. As no other recycling option are economically and technically available, our model includes only one alternative: solid waste selection and re-utilization (no other industrial form is considered). This option is presented in Fig. 4 and its results in Fig. 5.

Let us begin with municipal budget. In 1994 Puebla received from the federal government N\$13,055,000, which covers only 87% of the solid waste recollection; this budget does not contemplate the solid waste adequate deposit and ecological treatment. Local government spends more than it has only for re-locating refuses from one site to another. In the past, the local government has proposed a new tax on the waste recollection but this proposal has not been accepted by the community.

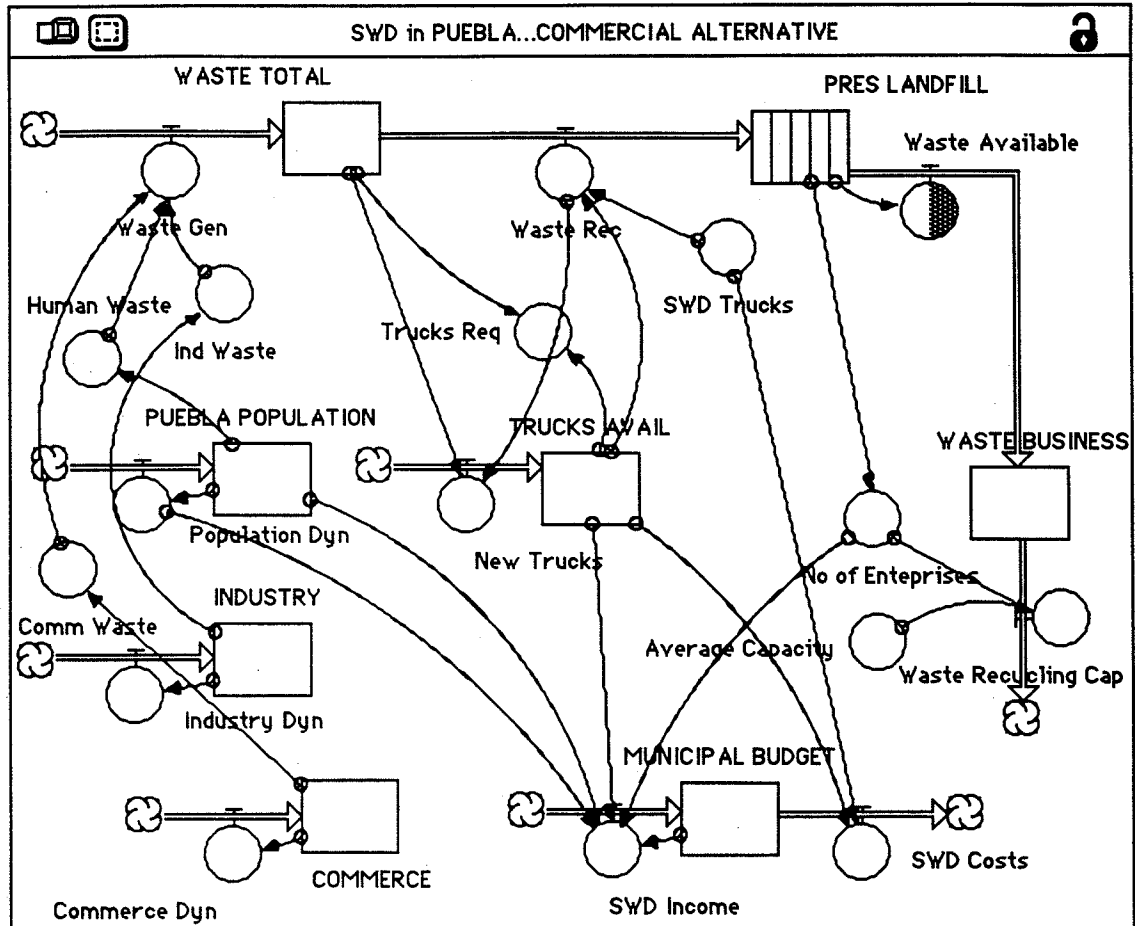
Proposed alternative not only makes it possible to avoid paying for refuse recollection and treatment but it also generate a positive municipal cash flow (industrial taxes paid by involved enterprises); we do not count additional employment source and other indirect economical benefits for the city and region of Puebla.

Another critical factor is the equilibrium between total amount of solid waste generated in Puebla and recycling capacity of the local industry. The variable "Waste Recycling" is calculated in the model as the percentage of the Total Waste. It is expected that after the liberalization of municipal policy and local laws, a significant initial cash inflow will occur; there are at least 5 companies with explicitly expressed interest in investing in waste recuperation: 3 from the United States, 1 from Canada, and another one is a national enterprise. These

companies submitted their solicitudes to the authorities' consideration about 2 years ago; we can think that any official public offer regarding the waste recycling industry should meet much broader response.

Fig. 4

Solid Waste Problem in Puebla. An Alternative

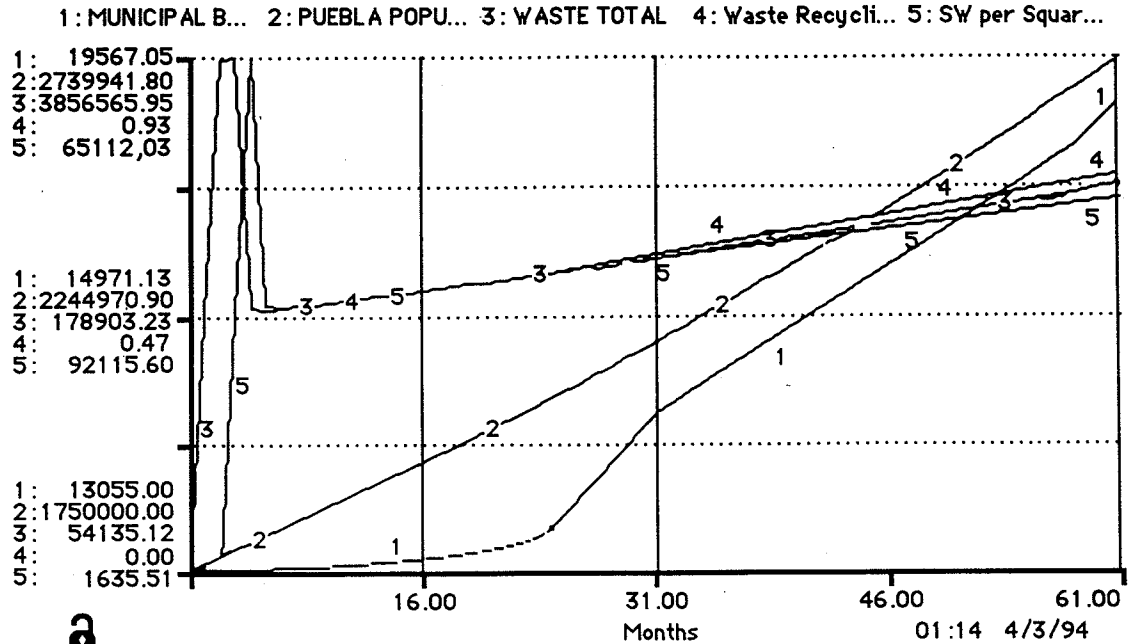


Final Remarks

Since long local government has been declaring its readiness to convert the solid waste management from the actual illegal landfill system into other forms of disposal, including re utilization and per house charging. No matter which plan is accepted, political, social, financial, and logistic aspects of the problem seem to exceed real possibility of solving it; the problem is getting worse and the licensing private enterprises to recollect solid wastes, solution already accepted by local government, cannot help. Instead of decreasing the scope of the problem, private licensing will "shift the burden" from the solid waste problem to budget expenditure question. A real problem of solid waste in Puebla does not reside in a sole refuse recollection but it rather requires dramatic changes in the ways local authorities think of it. Mistakes in the problem interpretation and lack of a proper analysis of the solid waste management objectives has resulted in the misperception of the problem scope. Instead of solving the problem, it is being substituted by its symbolic representation: budgetary constraints. Public presentation and comments on budget expenditure do not solve the problem; they rather search for a political legitimization of undertaken actions and usually provide a useful excuse for the environmental deterioration of Puebla.

Fig. 5

Alternative for Solid Waste Problem in Puebla. Results



Systems Thinking, and particularly System Dynamics methodology can offer a very reliable and attractive alternative for the re-definition of all public problems and for the re-shifting the attention and priorities of public administration. Unfortunately, there is a substantial gap between possible benefits from using the System Dynamics in this field and obstacles that must be overcome if the System Dynamics is really to become applicable. First of all, public managers are very reluctant to invest their time and energy in something "such isoteric" as the System Dynamics. They distrust it unless we show a "ready-to-go" model. This happened in this case; although the model presented in this paper lacks many important practical aspects, its elaboration was aimed more at causing more sensitivity to the specific solid waste problem than at proposing its definite solution. It seems that this objective has been achieved; when the model and its many runs were presented to local authorities responsible for the city cleaning system, we had a sound satisfaction to feel a threat and flattering distrust in our audience. Perhaps first step in mutual understanding?